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Anthropocene

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Abstract
Coined by two environmental scientists, the term "Anthropocene" is currently a buzzword in sections of the earth and environmental science community, as well as in the social sciences and humanities. It may in time assume the status of a "keyword" and become an established part of the academic lexicon. It describes human-induced changes to the earth's biophysical and chemical environment of such scope, scale, and magnitude as to mark the end of the Holocene (i.e., the roughly 11,700 years prior to the 21st century). The Anthropocene is thus an epochal term: it proposes that modern humans possess powers equivalent to the great forces of global nature - although these are unwitting powers that are the combination of countless everyday activities (e.g., driving to work) undertaken by billions of people. Though geographers did not invent the term, they have begun to focus on a range of issues directly relevant to it. Indeed, many have focused on these issues for years, only not with reference to the Anthropocene. Their interest covers the entire discipline of geography, from physical geography through environmental to human geography. This makes the Anthropocene an unusually promiscuous concept, even eclipsing "nature" and "environment" in its semantic reach. This is because it describes not merely "the human impact" on the nonhuman world but also the folding of human activity into earth-surface systems such that it becomes in some sense endogenous to those systems. This is not to imply that humans somehow "dominate" or "control" the earth but simply to acknowledge their newfound capacity to alter biophysical "boundary conditions" across multiple large-scale environmental systems. It is thus no surprise that a wide range of geographers have of late been attracted to the Anthropocene idea and its younger sibling: the concept of "planetary boundaries." Some physical and environmental geographers have advocated one or both of these ideas, along with others in the wider biophysical sciences. Meanwhile, several others are among the scientists seeking to verify or falsify these ideas empirically. These interventions have contributed to what thus far has been a debate centered on the environmental sciences and in geology. A number of human geographers who are less concerned about scientific issues of definition and measurement have concurrently begun to explore what the Holocene's end might mean for the future of humanity. Overall, current writings by geographers about the Holocene's proclaimed end are not cohesive; indeed, one would not expect them to be, and no practitioners have yet called for a more unified approach. They are a vibrant part of a much wider debate, currently an academic one for the most part, about whether we are in a new epoch of earth history and what it portends for life on the planet, both human and nonhuman. This debate should be seen as a continuation (perhaps even an amplification) of older discussions about the sort of "sustainable development" that is both possible and desirable in the future. In terms of geography this debate might eventually reprise, in new forms, grand discussions of human-environment relations that characterized its early decades as a university subject over a century ago. The difference is that these newer discussions will not presume there is a single approach that might reunite geographers across the long-standing divide separating their subject's physical and human components.

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Anthropocene: a geographical perspective forthcoming in B. Warf *et al* (eds) *Oxford Bibliographies: Geography*

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Introduction

Coined by two environmental scientists, 'The Anthropocene' is currently a buzzword in sections of the earth and environmental science community, so too parts of the social sciences and humanities. It may in time assume the status of a keyword, that is one of those terms that becomes an established part of the academic lexicon. It describes human-induced changes to the Earth's biophysical and chemical environment of such scope, scale and magnitude as to mark the end of the Holocene (that is, the roughly 11700 years prior to the present). The Anthropocene is thus an epochal term: it proposes that modern humans possess powers equivalent to the great forces of global nature, albeit unwitting powers that are the combination of countless everyday activities (e.g. driving to work) undertaken by billions of people. Though geographers did not invent the term, they have recently begun to focus on a range of issues directly relevant to it. Indeed, many have focussed on these issues for many years, only not with reference to the Anthropocene. Their interest covers the entire discipline of Geography, from physical geography through environmental to human geography. This makes the Anthropocene an unusually promiscuous concept, even eclipsing 'nature' and 'environment' in its semantic reach. This because it describes not merely 'the human impact' *on* the non-human world but, more than this, the folding of human activity into earth-surface systems such that it becomes in some sense *endogenous* to those systems. This is not to imply that humans somehow 'dominate' or 'control' Earth, but simply to acknowledge their new-found capacity to alter biophysical 'boundary conditions' across multiple large-scale environmental systems. It is thus no surprise that a wide range of geographers have of late been attracted to the Anthropocene idea and its younger sibling, the concept of 'planetary boundaries'. Some physical and environmental

geographers have advocated one or both of these ideas, along with others in the wider biophysical sciences. Meanwhile, several others are among the scientists seeking to verify or falsify these ideas empirically. These interventions have contributed to what so-far been a debate centred in the environmental sciences and in geology. A number of human geographers, less concerned about scientific issues of definition and measurement, have concurrently begun to explore what the Holocene's end might mean for the future of humanity. Overall, current writings by geographers about the Holocene's proclaimed end are not cohesive – indeed, one would not expect them to be and nor are any practitioners yet calling for a more unified approach. They are a vibrant part of a much wider debate, currently academic for the most part, about whether we are in a new epoch of Earth history and what it portends for life on the planet, human and non-human. This debate should be seen as a continuation, perhaps even amplification, of older discussions about the sort of 'sustainable development' that is both possible and desirable looking ahead. For Geography this debate might eventually reprise, in new forms, grand discussions of human-environment relations that characterised its early decades as a university subject over a century ago. The difference is that these newer discussions will not presume there is a single approach that might reunite geographers across the long-standing divide separating their subject's physical and human components.

General Overviews

The Anthropocene is a profoundly geographical idea in that it represents modern humans as, quite literally, geo-graphers ('Earth writers' or terraformers) on an epic scale. Yet it originates outside Geography in a network of environmental scientists – a network strongly linked to the International Geosphere-Biosphere Program (IGBP), one of the several 'global environmental change' research programs established by leading governments around 25 years ago. Because the 'Anthropocene hypothesis' is still relatively new – first being proposed in-print in 2000 and not really 'pushed' by its originators until 2007 onwards – there are, as yet, no general overviews of the subject that cover the environmental science, social science and humanities dimensions. Instead, there is a set of (mostly) readable articles authored by several scientists – writing together in various combinations – keen to explore the idea that the Holocenemay now be ending. As the Anthropocene is older than the related idea of 'planetary boundaries' there are more articles pertaining to the former. Regardless, almost all the articles treat the Holocene's end as a scientific question in the first instance, wherein rates of current environmental change can be compared to past rates in order to ascertain if a qualitative shift has already occurred in Earth history (or is now occurring). But this scientific focus notwithstanding, these publications all have a clear, though often implied, normative edge: namely, that modern humans must, via their governmental representatives and other means, fundamentally change their activities to ensure the Holocene's end does not mark the beginning of an inhospitable planet for humans and many other species. This normative agenda amplifies existing scientific research about anthropogenic climate change and biodiversity decline that goes back at least 30 years. In this sense, the scientists hypothesising that the Holocene has ended (or is now ending) can be seen as 'concerned scientists' building on a decades-old tradition of experts speaking-out when they perceive erstwhile scientific issues having large societal implications. Some environmentalists would like them

to be even more outspoken. The inaugural statement of the Anthropocene hypothesis was made by Crutzen and Stoermer 2000, followed two years later by a high-profile solo statement in the journal *Nature* by Crutzen. Thereafter, a more complete statement was made by Steffen, Grinevald, Crutzen & McNeill 2011 and by Steffen *et al*. 2011. Prior to these, the Anthropocene was evoked in all but name in the first 'big book' to come out of the IGBP, that authored by Steffen *et al.* 2004.

Crutzen, Paul, Joseph and Eugene Stoermer. "The Anthropocene." *Global Change Newsletter* 41 (2000): 17-18. Reproduced in *The Future of Nature*. Libby Robin, Sverker Sorlin, and Paul Warde (Eds) pp. 483-5. New Haven: Yale University Press, 2013

A short essay published in a news letter circulated to those formally part of, and those interested in, the International Geosphere-Biosphere Program. It proposed that the Holocene may have ended and suggested a date (1800) when the Holocene 'boundary conditions' began to alter significantly. Not easy to track down, it has recently been republished in an anthology of writings about global environmental change edited by environmental historian Libby Robin and others.

Crutzen, Paul. "Geology of Mankind." *Nature* 415, January 3rd (2002): 23.

Crutzen reprised the hypothesis put forward in Cruzten and Stoemer 2002, only now for a much wider scientific audience.

Steffen, Will, Jacques Grinevald, Paul Crutzen & John McNeill (2011) "The Anthropocene: conceptual and historical perspectives." *Philosophical Transactions of the Royal Society* A 369 (2011): 842-67.

One of two 2011 papers that offer an extended presentation of the idea that the Holocene is finished. Written for a general scientific audience it does two things. First, it presents a battery of evidence demonstrating the accelerating rate of global environmental change, including but extending well beyond anthropogenic climate change. Second, it attempts to periodise the Anthropocene, distinguishing the 'Industrial Era' (1800-1945) from 'The Great Acceleration' (1945-today).

Steffen, Will *et al. Global Change and the Earth System: A Planet Under Pressure.* Berlin: Springer-Verlag, 2004.

This work of scientific synthesis uses an Earth System Science approach to highlight the large, interconnected environmental changes instigated by humans in the modern era. Much of the evidence assembled in the book forms the basis for later papers which argue that the Holocene may have now ended.

Steffen, Will *et al.* "The Anthropocene: from global change to planetary stewardship." *Ambio* 49, 5 (2011): 739-61.

Written by sixteen authors, this essay extends the argument presented in Steffen, et al. 2004 in two ways. First, it assumes the Holocene has, in fact, ended and explores how humanity

should respond – highlighting the need for 'planetary stewardship'. Second, it discusses the concept of 'planetary boundaries' – about which more in *Planetary Boundaries*.

Journals

There are three journals dedicated to exploring the full spectrum of scientific issues associated with the Anthropocene concept. They are ***Anthropocene***, published by Elsevier, ***The Anthropocene Review***, published by Sage, and ***Elementa: Science of the Anthropocene***, published by a consortium of American universities . Theircontentsrange from empirical issues (measuring rates of environmental change) to conceptual issues (for instance, modelling coupled changes between different Earth surface sub-systems) to historical issues (for instance, when can the Anthropocene be said to have begun?). Both journals are new. So far, *The Anthropocene Review* has achieve a wider intellectual coverage of the issues, assembling papers by environmental scientists, geologists, social scientists and humanities scholars in its early volumes. These three journals aside, there are some established peer review journals that are beginning to publish articles on the scientific aspects of the Anthropocene and planetary boundaries. Two notable cases are ***Global Environmental Change*** and ***Earth Perspectives*.**

**Anthropocene*[http://www.journals.elsevier.com/anthropocene/]*

A cross-disciplinary peer review journal but with a largely scientific feel. To use the editor's own words, it "publishes peer-reviewed works addressing the nature, scale, and extent of the influence that people have on Earth. The scope of the journal includes the effects of human activities on landscapes, oceans, the atmosphere, cryosphere, and ecosystems over a range of time and space scales - from global phenomena over geologic eras to single isolated events - including changes to the exchanges, linkages, and feedbacks among the systems".

**The Anthropocene Review*[http://www.uk.sagepub.com/email/online/2013/3C82.htm]*

A cross disciplinary peer review journal that includes articles authored by various environmental scientists, geologists, social scientists and humanities scholars. At the time it was launched (2013) it had thoroughly transdisciplinary aspirations that have thus far been realised. According to the publisher's home page for the journal, it "is the first high profile international journal to address explicitly all aspects of the Anthropocene, from earth and environmental sciences, material sciences, social sciences and the humanities".The journal seeks to examine the socio-economic and cultural causes of global environmental change, the physical and societal effects of such change, and a range of possible human responses to change (from technical ones to behavioural ones.

**Elementa : Science of the Anthropocene* [http://elementascience.org/]*

A new online, open-access, peer review journal emphasising scientific perspectives on global environmental change and societal responses. It has three main foci : understanding interactions between components of an Earth system experiencing anthropogenic change;

understanding the complex ‘couplings’ of environmental change and human actions; and exploring measures to mitigate and adapt to global environmental change. The knowledge domains defining its remit are atmospheric science, ocean science, ecology, earth and environmental science, sustainable engineering and sustainability transitions.

Global Environmental Change[http://www.journals.elsevier.com/global-environmental-change/]

An established international, interdisciplinary peer review journal spanning the social and natural sciences, it sometimes publishes articles that discuss aspects of the Anthropocene hypothesis, and the related idea of planetary boundaries. It publishes many article about the causes and effects of anthropogenic climate change, and various actual or possible human responses to such change. It tends to contain articles with a mainstream or critical social science flavour, rather than those authored by environmental scientists.

Earth Perspectives[http://www.earth-perspectives.com/]

A new open access peer review journal, it grows out of Earth System Science and aims to include articles on the human dimensions of global environmental change not just the biophysical dimensions. It has a mainstream science character and rarely publishes radical social science articles or those authored by environmental humanists.

Geological and Environmental Science Debates

Though not first proposed by geologists, the epochal meaning of the Anthropocene idea meant, unsurprisingly, that it was soon noticed by members of the geology discipline. Their concern was that it was being used by non-some non-geologists as if it were a formal geological unit before the geological community had formally assessed the evidence. Geologists distinguish epochs of Earth history in one or both of two ways: namely, by identifying a Global Stratigraphic Section and Point (‘golden spike’) locations within geological strata and/or by adopting a numerical date that corresponds to the onset of demonstrable and significant concurrent environmental changes on different parts of the planet’s surface. This means that for geologists to accept that the Holocene has ended there is a need for clear and global evidential markers and/or a need for these markers to cluster around a numerical date in terms of their first appearance. Zalasiewicz *et al*. 2008 outline the criteria that need to be satisfied for the Anthropocene to be considered a new epoch in Earth history. Almost all of the 21 authors reprise the argument at greater length in Zalasiewicz *et al*. 2011. These authors are members of Stratigraphy Commission of The Geological Society (located in London). More recent contributions by Ellis 2011, Brown *et al*. 2012, Gale and Hoare 2012, Rull 2013 and Lewin and Macklin 2013 consider the weight of current evidence pertaining to evidential markers (mostly numerical date-related ones). These recent contributions have been made by environmental scientists rather than geologists. This is because the contemporary character of anthropogenic environmental change means we do not yet have a ‘deep’ geological record akin to the records we have for previous epochs of Earth history. It follows that all branches of environmental science (including all branches of physical geography) are potentially relevant to the evidential question of

whether and when the Holocene ends . This is still relevant to geology, however, because modern humans (since aobut 1800) may already have left a distinctive stratal imprint overlaid on the many olders ones in Earth history. Ruddiman 2013 expertly outlines the historical debates pertaining to a numerical date when the Anthropocene can be said to have begun. Smith and Zeder 2013 cover much of the same ground but more succinctly. At the time of writing the International Commission on Stratigraphy – which is ultimately responsible for identifying geological epochs – established an Anthropocene Working Group and made Zalasiewicz its chairman.Some of its members – namely Waters *et al*. 2014 – have recently published a review the parameters used by stratigraphers to identify chronostratigraphical units and how these could apply to the definition of the Anthropocene. A few geologists believe work of this sort is in vain. Autin and Holobrook 2012, for instance, see the Anthropocene as a 'pop culture' concept of little value to geologists.

Autin, Witney and John Holbrook. "Is the Anthropocene an issue of stratigraphy or pop culture?'" *GSA Today* 22, no. 7 (2012): 60.

A commentary in the 'house periodical' of the Geological Society of America, it sees two geologists question the value of the Anthropocene hypothesis. The authors suggest it is a 'new times term' better suited to public and politicians' debates about environmental management than epochal changes in Earth history.

Brown, Antony. G. *et al*. "The Anthropocene: is there a geomorphological case?" *Earth Surface Processes and Landforms* 38, no. 3 (2012): 431-4.

Explains how geomorphology can provide evidence germane to the determination of whether or not the Anthropocene can be said to be a new geological epoch.

Ellis, Erle. "Anthropogenic transformation of the terrestrial biosphere." *Philosophical Transactions of the Royal Society* A 369 (2011): 1010-35.

Authored by a biogeographer, this article suggests there is a *prima facie* case for the end of the Holocene, focussing on the worldwide decline of 'natural biomes' and their replacement by various 'anthromes'.

Gale, Stephen and Peter Hoare. "The stratigraphic status of the Anthropocene." *The Holocene* 22, no. 12 (2012): 1491-4.

This short article suggests soil profiles cannot be useful evidential markers for determining the onset of the Anthropocene and raises critical questions about the possibility of identifying either a 'Golden Spike' or a numerical date for its onset.

Lewin, John and Mark Macklin. "Marking time in geomorphology: should we try to formalize an Anthropocene definition?" *Earth Surface Processes and Landforms* (2013) DOI: 10.1002/esp.3484.

Argues that it may be impossible to show that the Anthropocene satisfies geological criteria for the onset of a new Earth epoch, but that the idea may have informal use as device that

sensitises researchers and others to the remarkable scale of anthropogenic environmental change.

Ruddiman, William. “The Anthropocene.” *Annual Review of Earth & Planetary Science* (2013) DOI: 10.1146/annurev-earth-050212-123944.

An up-to-date review of most of the evidence relevant to determining both whether and when the Anthropocene can be said to have begun. It is, however, less interested in satisfying geological criteria for the onset of a new epoch than most geologists would be.

Rull, Valenti. “A futurist perspective on the Anthropocene.” *The Holocene* (2013) DOI: 10.1177/0959683613483628: 1-4.

This brief article suggests that debates about the geological status of the Anthropocene should not determine whether the Anthropocene concept is useful as a representation of contemporary environmental change.

Smith, Bruce and Melinda Zeder. “The onset of the Anthropocene.” *Anthropocene* (2013) DOI: 10.1016/j.ancene.2013.05.001’

This recent review article summarises the issues of periodisation pertaining to the onset of the Anthropocene and assesses the evidence. It has an eye both on the debates in geology and wider discussions about environmental changes in the environmental sciences.

Waters, Colin *et al*. “A stratigraphical basis for the Anthropocene.” The Geological Society, special publications (2014) DOI: 10.1144/SP395.18

Authored by geologists, this article considers how various environmental changes caused by humans might manifest as stratigraphic signals that can be used to describe an Anthropocene strata and to recognize its base.

Planetary Boundaries

In a short paper Rockström *et al*. 2009a have advanced the concept of ‘planetary boundaries’. This concept is elaborated and evidenced at much greater length in Rockström *et al*. 2009b. The idea is directly linked to the Anthropocene concept in two ways. First, some of the proponents of the latter have lent their names to the former (notably Nobel Prize winner Paul Crutzen). Second, like the Anthropocene concept, the planetary boundaries idea refers to all the major Earth surface systems that together sustain life. Where it differs is in specifying quantifiable biophysical boundaries, the transgression of which is said by Rockström *et al*. to risk seriously undermining human life and life on Earth more generally. The idea has more of an overt normative edge than the Anthropocene concept, captured in the term ‘safe operating space for humanity’ used by Rockström and colleagues. For this reason it was foregrounded in a special ‘environmental issue’ of *Scientific American* in April 2010 and, later, at the 2012 ‘Planet Under Pressure’ conference in London – an event that was designed to alert the world’s leading politicians to environmental threats ahead of the so-called ‘Rio+20’ Earth Summit.

Because of its intended relevance to international government policy, Lewis reflects on how the idea might best be communicated to politicians. Meanwhile, Nordhaus, T., Shellenberger, M. & Blomqvist 2012 offer the first independent assessment of the scientific plausibility of the planetary boundaries idea. Cornell 2012, by contrast, seeks to clarify some of the conceptual underpinnings of the concept. Others, such as Carpenter and Bennett 2011, have sought to more accurately quantify some of the boundaries Rockström and co-workers identify.

Carpenter, Stephen and Bennett, Elena. “Reconsideration of the planetary boundary for phosphorus”. *Environ. Research Letters* 6, January-March (2011) DOI:10.1088/1748-9326/6/1/014009

Refines Rockström *et al.*’s quantitative estimate for a planetary boundary for levels of phosphorous deposition in the world’s oceans and seas.

Cornell, Sarah. "On the System Properties of the Planetary Boundaries". *Ecology and Society* 17, no. 1 (2012): r2. DOI: 10.5751/ES-04731-1701r02.

Offers conceptual clarification on how the properties of linked Earth surface sub-systems might be best represented by Johan Rockström and his coauthors.

Lewis, Simon. “We must set planetary boundaries wisely.” *Nature* 485, 24th May (2012): 417.

A short piece by a sympathetic scientist, it offers insights into how successful the planetary boundaries idea is likely to be in altering politicians’ perceptions of what environmental threats should be prioritised in policy terms.

Nordhaus, Ted, Michael Shellenberger and Linus Blomqvist. *The Planetary Boundaries Hypothesis: A Review of the Evidence.* Oakland: Breakthrough Institute, 2012.

A systematic review of the evidence for and against the planetary boundaries hypothesis authored by three independent analysts. It points to the implicit social judgements written-into the claims made by Rockström and colleagues. It also questions whether some of the nine supposed boundaries are measurable at a global scale.

Rockström, Johan *et al.* “A safe operating space for humanity.” *Nature* 461, 24th September (2009a): 472-5.

Argues that the environmental conditions of the Holocene are preferable to those of an unknown and potentially inhospitable Anthropocenic future. It identifies nine global environment components constitutive of the Earth system. These pertain to climate and ocean acidity among other things. For seven, the authors specify a quantitative boundary, the crossing of which might take the system beyond Holocene norms (for the remaining two they are unable, as yet, to quantify the boundary). Modern humans, they argue, have already transgressed several of these.

Rockström, Johan *et al*. “Planetary boundaries: exploring the safe operating space for humanity.” *Ecology & Society* 14, 2 (2009b): 1-24.

This article is a more detailed version of Rockström *et al.* 2009a and appears in a less high-profile science journal than the shorter companion paper in *Nature*.

Earth System Science

Many of the environmental scientists who have advanced either the Anthropocene or planetary boundaries hypotheses have been advocates of Earth System Science (ESS). This is global physical geography by another name, examining recent environmental change against the background of a much longer Earth history. Itwas first suggested as a scientific priority in the mid-1990s. Interdisciplinary in nature, it considers the interactions between the atmosphere, hydrosphere, lithosphere, biosphere and heliosphere. The original public ‘manifesto’ for ESS was published by Schellnhuber 1999. The first significant conceptual and empirical fruits of ESS were presented in Clark, Crutzen and Schellnhuber 2004. Clifford and Richards 2005 raise some critical questions about the intellectual value and political implications of ESS. Their critique, though it does not engage with the idea that the Holocene has ended, is relevant to the science underpinning both the Anthropocene and planetary boundaries hypotheses.

Clark, William C., Paul Crutzen, and Hans-Joachim Schellnhuber (Eds) *Earth System Analysis for Sustainability*. Cambridge, MA: MIT Press, 2004,

Among the first books to bring together scientists looking at recent trends on the state of separate biophysical systems, and these systems are coupled.

Clifford, Nick and Keith Richards. “Earth System Science: An Oxymoron?”. *Earth Surface Processes and Landforms* 30, no. 3 (2005): 379-83.

Among the first critical engagements with ESS, it argues that this ‘super-discipline’ should be regarded with some caution because of its desire to make global, encompassing claims about nature that stand to influence policy decisions that will affect the lives of billions of people.

Schellnhuber, Hans Joachim. “‘Earth system’ analysis”. *Nature* 402, 2nd December (1999): 19-23.

Argues that we have both the technical capacity and good environmental reasons to undertake detailed analysis of the interlinked biophysical systems humans are altering at the global scale.

Science-Society Relationships

Those proposing the idea that the Holocene is at an end recognise the key role that environmental science can play in shaping the domestic and international policies of national governments worldwide. The Intergovernmental Panel on Climate Change has set a precedent for global environmental science feeding into government policy at the global scale, cascading down to the national and sub-national levels. What is more, the societal implications of the hypothesis that the

Holocene has ended are potentially profound. Consequently, many environmental scientists are now looking to social scientists and humanities scholars for assistance in showing politicians what the options are for altering human behaviour so as to prevent 'dangerous' anthropogenic environmental change. Walter Reid and colleagues (including Paul Crutzen and Johan Rockström) 2009 call for a transdisciplinary 'sustainability science' that can assist governments and citizens in responding to Earth system changes. DeFries *et al*. 2013 echo this, but use the concept of 'planetary opportunities' to frame their discussion of 'action-orientated' research in the service of society. More recently, Griggs *et al*. 2013 propose new sustainable development goals for the United Nations that blend the existing Millennium Development Goals with the caution that humanity cannot exceed a 'safe operating space'. Meanwhile, a group of environmental social scientists have recently argued that the Holocene's end demands a revolution in the way both environmental and social scientists work. This revolution is necessary, O'Brien *et al*. 2013 argue, because it is precisely existing habits of thought and practice that have pitched the Earth into potentially dangerous *terra incognita*. Their argument is echoed by Palsson *et al*. 2013, who suggest that future debates about the Anthropocene not be dominated by environmental scientists or geoengineers. Castree *et al*. 2014 show how critical social scientists and humanists might constructively shape debates and decisions about Earth future, working with environmental scientists without being overshadowed by them.

Castree, Noel *et al*. "Changing the intellectual climate". *Nature Climate Change* 4 (2014): DOI 10.1038/NCLIMATE2339

Authored by an international group of environmental social scientists and humanists, it shows why and how environmental scientists cannot adequately address the societal problems posed by global environmental change without collaborating with those who study human values, institutions and behaviours.

DeFries, Ruth *et al*. "Planetary opportunities". *Bioscience* 62, no. 6 (2013): 603-606.

Authored by environmental researchers hailing from multiple disciplines, it calls for a 'new social contract' wherein scientists focus on workable solutions to problems created by anthropogenic environmental change.

Griggs, David, Mark Stafford-Smith, Owen Gaffney, Johan Rockström, Marcus Öhman, Priya Shyamsundar, Will Steffen, Gisbert Glaser, Norichika Kanie and Ian Noble. "Sustainable development goals for people and planet". *Nature*, 495, 21st March (2013): 305–307.

A manifesto for 'sustainable development' informed by the science of 'planetary boundaries', thus adding a new emphasis to the concept first expounded by the Bruntland Commission nearly thirty years ago.

O'Brien, Karen *et al.* "You say you want a revolution? Transforming education and capacity building in response to global change." *Environmental Science and Policy* 28, no. 1 (2013): 48-59.

Presents 'out of the box' ideas for how the global environmental change research community can achieve an 'axial revolution' in its way of thinking about how to tackle present and future environmental problems attendant upon the Holocene's end.

Palsson, Gisli *et al*. "Reconceptualizing the 'Anthropos' in the Anthropocene: integrating the social sciences and humanities in global environmental change research.". *Environmental Science and Policy* 28, no. 1 (2013): 3-13.

Makes a case for how the social sciences and humanities can offer societies new ideas and new solutions without becoming mere appendages of an environmental science-led, technocratic approach to 'managing' future environmental threats.

Reid, Walter *et al*. "Earth System Science for Global Sustainability: Grand Challenges". *Science* 330, 12th November (2010): 916-7.

Calls for the several international 'global environmental change' research programs to better connect the science to the social questions of what should be done and how. It a more guarded way, it echoes the agenda presented by Palsson and colleagues.

Critical responses in the social science and humanities

The Anthropocene idea, and that of planetary boundaries, have large and wide implications for thinking about humanity's place on Earth and its future. Because it this, they have caught the attention of social scientists and humanists who are concerned about the scale and scope of the human impact on nature. Some have objected to the decision to label our epoch the Anthropocene, though not because they want to downplay the idea that modern humans are rapidly degrading Earth's environment. Malm and Hornborg 2014 argue that degradation is not caused by humans as such, but by a humanly created and now globally dominant economic system (capitalism). Scientists like Crutzen are thus helping to conceal the root causes of our environmental woes by promoting the term Anthropocene. More radically, environmentalist Eileen Crist 2013, regards the language used by geoscientists deeply anthropocentric and anti-ecological, even as it appears to express concern about our ecological condition. Meanwhile, anthropologist Deborah Bird Rose 2013 sees in the Anthropocene idea the potential to fundamentally question growth-orientated, consumption-obsessed Western societies. But she believes geoscientists like Crutzen are necessarily constrained in the language they use when criticising the environmental damage humans are inflicting on Earth.

Bird Rose, Deborah. "Anthropocene noir". People and Planet Conference Proceedings, RMIT University, Melbourne: http://global-cities.info/news-events/conferences-forums/conferences-proceedings

Explores the idea of a dark, less lively Earth implicit in the Anthropocene concept but not highlighted by its scientific advocates.

Crist, Eileen. "On the poverty of our nomenclature". *Environmental Humanities* 3 (2013): 129-47.

Takes issue that the family of terms geoscientists have been using to talk about the Anthropocene, such as 'systems', 'impacts' and 'management'. Crist argues that these terms express an anti-ecological attitude that objectifies the non-human world. For her they cannot express the murderous effects of humans on nature nor express the emotional attachment needed to properly care for it.

Malm, Andreas and Hornborg, Alf. "The geology of mankind?". *The Anthropocene Review* 1, 1 (2014): DOI 10.1117/2053019613516291

Challenges the idea, implicit in the Anthropocene concept, that 'humans' as a species are responsible for the enormous physical changes Earth is experiencing. The authors argue that the capitalist mode of production has led many (not all) modern humans to engage in environmentally careless and harmful practices.

Contributions to Debate by Physical and Environmental Geographers

Despite their obvious relevance to the various branches of contemporary physical geography, relatively few environmental scientists based in Geography have as yet contributed to the scientific debates about the Holocene's putative end. Likewise, few geographers who examine large-scale human impacts on the physical environment have contributed to these debates or related ones about how humans might respond to life in the Anthropocene. This is not in any sense a problem, not least because the analysis of physical geography and the human impact does not begin-and-end with Geography as a discipline. Indeed, aside from the geologists whose publications are summarised in *Geological and Environmental Science Debates* **above** no single discipline can claim to be a main contributor to the scientific discourse to-date. Within physical geography, however, one person has been more vocal than most of his peers. Erle Ellis has made a number of scientific and more popular contributions to current understandings of the Anthropocene. His scientific work focuses on 'anthromes' or anthropogenic ecosystems, a recent example being Ellis *et al* 2013. However, Ellis has ventured beyond the science to offer a view about how the advent of the Anthropocene should alter current approaches to nature conservation and management. For instance, in a 2009 *Wired* magazine he advocated 'post-naturalism', a form of environmental politics and policy that no longer aims to protect 'nature'.

Ellis, Erle. "*Stop trying to save the planet[http://www.wired.com/wiredscience/2009/05/ftf-ellis-1/]*." *Wired* magazine June 6th (2009):

An op-ed that offers a criticism of an approach to environmental management that uses 'nature' as a benchmark and criteria of success.

Ellis, Erle *et al*. "Used planet: a global history". *PNAS* 110, no. 20: 7978-85.

This multi-authored science article presents strong evidence that humans were significant shapers of the world's ecology well before the modern industrial period.

Human Geography and the End of the Holocene

If one takes the Anthropocene and planetary boundaries hypotheses seriously, then modern humans – and more particularly those enjoying lifestyles that involve large environmental inputs and outputs – are literally geo-graphers ('Earth-writers'). This invites a consideration of why and how humans have become a planetary force (sheer population numbers?; advanced technologies?; the blind pursuit of money? …). It begs questions about how societies ought best to respond, both separately and acting in concert. It also begs questions about the validity of categories of 'human' and 'physical' that for many decades have cleaved academic Geography into two heterogenous parts, between which an equally diverse field of environmental (or 'human-environment') geography has sat. Human geographers have been writing about all these questions for some years now, though only recently with formal reference to the Anthropocene and planetary boundaries concepts. This writing has served to bring the non-human 'back in' to human geography such that some commentators now talk about a 'more-than-human-geography' as a major development in Geography as a whole. A good deal of this writing is practically-orientated, aiming to offer arguments, evidence and ideas in the service of reforming current socio-economic systems so they can be more ecologically sustainable and more environmentally just. However, some of this writing is more radical and makes the case for a thorough reworking of these systems and of the academic disciplines that help to reproduce them. Given the potential enormity of the subject areas that can be covered, so far human geographers' discussions of life in the Holocene have understandably been diverse and patchy. The focus has been on how one should respond to the claims made by scientists like Paul Crutzen (co-inventor of the Anthropocene concept); on how one should respond to the prospect of an Earth transformed well beyond Holocene conditions; and on how one should conceive of the 'human'.

Social implications of earth and environmental science

Human geographers vary in their stance towards those scientists proposing that the Holocene is at an end. Lorimer 2012 is inspired by the increasingly 'post-natural' science of conservation biology. For him humans are creating, without ever controlling, 'emergent biogeographies' that are spatially and temporally varied, often surprising. Robbins and Moore 2013, by contrast, worry that conservation science is still gripped by classical scientific assumptions that there is a physical world 'out there' that can be understood 'objectively' and managed without humans imposing their values and beliefs. Dalby 2013, meanwhile, worries that national politicians may use the science in order to justify security policies that can be seen as punitive and defensive to many.

Dalby, Simon. "Biopolitics and climate security in the Anthropocene." *Geoforum* 49, no. 1:184-92.

If the Anthropocene idea catches-on in the world of national and international politics, Dalby rightly argues that critical scrutiny of the resulting geopolitical discourses – which may be rather novel ones – is important. He calls upon human geographers to invent a new repertoire of ideas that might help humans produce a future world where inter-state cooperation and peace largely characterise the response to Anthropocenic change

Lorimer, Jamie "Multinatural geographies for the Anthropocene." *Progress in Human Geography* 36, no. 5 (2012): 593-612.

This review article takes inspiration from conservationists who no longer make reference to an asocial Nature to justify various management/conservation/remediat-ionpreservation/restoration measures (be they large or small). Lorimer argues for an 'experimental ethos' in which humans actively 'graph the bio' with sensitivity and concern.

Robbins, Paul and Sarah Moore. "Ecological anxiety disorder: diagnosing the politics of the Anthropocene." *Cultural Geographies* 20, no. 1 (2013): 3-19.

Diagnoses 'ecological anxiety disorder' among contemporary conservation biologists and argues that environmental science in the Anthropocene needs to do a better job of admitting the 'human factor' in scientific analysis and related policy prescriptions. Unlike Lorimer, it does not believe scientists are yet ready to recognise their science as 'post-natural'.

Social responses to an Earth transformed

Several human geographers want a sea-change in socio-economic and political life adequate to the challenges future Earth surface change will pose. But they differ about what kind of change is required, and whether it will occur at all. O'Brien 2013 addresses the 'mainstream' community of global environmental change researchers (including many human geographers), while Gibson-Graham sees the Holocene's end as an occasion to look for socio-ecological alternatives that expressly challenge the mainstream.

O'Brien, Karen. "Global environmental change III: closing the gap between knowledge and action." *Progress in Human Geography* 37, no. 4 (2013): 587-96.

This review offers reasons and mechanisms that might inspire a significant questioning of current lifestyles and of modes of analysis that implicitly or overtly sustain them. O'Brien calls for a root-and-branch questioning of social assumptions about what is 'normal' and 'acceptable', so as to engender a step-change to mainstream society and its institutions. This will require human geographers and fellow travellers to overturn their paradigmatic practices.

Gibson-Graham, Julie-Kathy. "An economic ethics for the Anthropocene." *Antipode* 41, S1 (2009): 320-46.

Two leading human geographers argue that the advent of the Anthropocene can inspire more people to create alternatives to consumer-capitalism. They argue for a new ethos of engagement with other people and non-humans that is inspired by people's own creativity and the world's capacity for surprise and novelty. The point to experiments in 'alternative living' beyond the societal mainstream. In this sense they amplify the arguments made by Lorimer 2012 (cited under *Social implications of earth and environmental science*).

The ontological status of the human

In recent years a number of human geographers have started to question the apparent solidity of the category of 'the human', questioning the ontological distinctness of the category's referent. Not only does this challenge the topical separation between human and physical geography; it also has practical, ethical and aesthetic implications for Western societies that presume the world to be cleaved into ontological domains like social and natural. Clark 2012 examines the ethical implications of humanity's overdue recognition that it is not separate from nature's big forces, while Yusoff 2013 makes the ontological case for humanity's geological character.

Clark, Nigel. "Rock, life, fire: speculative geophysics and the Anthropocene." *The Oxford Literary Review* 34, no. 2 (2012): 259-76.

> Argues that the Anthropocene forces upon those of us the recognition that we are thoroughly *earthly* creatures, not simply fleshy, biological ones: we are simultaneously emergent from, dependent upon and at times vulnerable to a plethora of living and non-living phenomena. Clark hopes that the Anthropocene's onset can engender a new sensibility in Geography and the wider world, one more attuned to both the 'more-than-human' (e.g. plants or insects) *and* the 'inhuman' (i.e. those biophysical forces capable of destroying us).

Yusoff, Kathryn. "Geologic life: prehistory, climate, futures in the Anthropocene." *Society & Space* 31, 5 (2013): 779-95.

> Argues that an attention to *homo sapiens*' emergence and a focus on our current terraforming powers together call into question the solidity of the category of 'the human'. Yusoff makes the case that Western societies should now give up on the conceit that people are somehow separate from the 'big natural forces' that typically have appeared to be the stable background of our existence.